Isotopes in Chemistry

Isotopic Studies of Heterogeneous Catalysis. ATSUMU OZAKI. Kodansha, Tokyo, and Academic Press, New York, 1977. viii, 240 pp., illus. $25.

Isotopic tracers provide the most powerful tools for investigating the mechanisms of chemical reactions. This book by Ozaki is the most comprehensive, well-written, and useful treatise that has been published on the application of these techniques to heterogeneous catalysis. It should be a prime resource to all serious researchers who are studying the fundamentals of catalysis.

Beginning with a rather abbreviated discussion of analytical methods and a beautiful section on the mathematical formulation of rate equations for isotopic exchange, the book deals primarily with specific examples in which isotopic tracers have been used to shed light on the activity of catalytic surfaces, the nature of adsorbed species, reaction pathways, and rate-limiting steps in catalytic reactions. Over 700 references introduce the reader to a wealth of detailed information from all over the world, which is accurately and succinctly summarized in the book. Occasional footnotes referring to papers that were published while the book was being printed assure that the material is current. In addition to the usual author and subject indexes, there is a catalyst index that greatly enhances the utility of the book.

Essentially all known types of catalytic reactions have been investigated with the use of isotopic tracers; most of these are mentioned somewhere in the book. Ozaki has done extensive isotopic tracer studies of ammonia synthesis catalysts, and he covers this topic most thoroughly. In addition, there is excellent coverage of oxidation and ammoxidation (evidence for allylic-type intermediates), catalytic cracking (carbonium ion surface species), hydrogenation (singly and multiply bonded complexes), and dehydrocyclization (dual functional sites). Both stable (deuterium and ^{13}C) and radioactive (^{14}C) tracers have shed light on the bond rearrangements that occur during the intriguing disproportionation (metathesis) reaction of propylene into 2-butene and ethylene. That skeletal isomerization of hydrocarbons proceeds through cyclic intermediates has been clearly demonstrated by use of ^{13}C tracers. Reactions involving CO and H_2 to produce synthetic fuels and chemicals (for example, Fischer-Tropsch and methanol synthesis) are also covered.

Most types of commercial and experimental catalysts are dealt with. These include all electrical types from insulators to semiconductors to conductors; in composition they encompass electron donors and acceptors, oxides, and metals.

The last chapter, on isotope effects, is particularly useful, for it beautifully ties together a vast range of rather fragmentary information. Tables comparing results from various laboratories allow one to see at a glance areas where there is agreement—and sometimes disagreement. In several places where there is apparent conflict, Ozaki has offered reasonable explanations for the discrepancies. Throughout the book, brief summarizing statements listing the major conclusions follow the presentation of results.

Several important review articles are cited in the book. The only omission I noticed was of the published proceedings of a symposium organized by Happel and Hnatow, "The Use of Tracers to Study Catalytic Reactions" (*Ann. N.Y. Acad. Sci.* **213** [1973]). Ozaki's book is an extremely important one in catalysis, and I heartily recommend it.

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Atomic Scattering

Potential Scattering in Atomic Physics. P. G. BURKE. Plenum, New York, 1977. viii, 138 pp. $22.50.

There exist several books on the subject of potential scattering in atomic physics that are more comprehensive than the present one. What Burke has attempted to give here is a distillation of some of the modern developments of the theory of electron scattering from atomic systems (including atoms and ions but not molecular targets). In a sense the title of the book is too narrow—the theory encompasses effects in elastic scattering coming from many electron targets, notably exchange. What are not included are the many-channel effects associated with excitation and ionization.

The first chapter is really a preface. The next two chapters cover essential background material: the partial wave expansion for potential scattering as well as scattering from a Coulomb potential. Because the treatment is brief, no discussion of peripheral yet important points is given. For example, there is no mention of the interesting paradoxes, so well discussed in Schiff's *Quantum Mechanics*, implicit in the idealization of an infinitely wide incident beam in the time-independent treatment of scattering.

The fourth and fifth chapters deal with the exchange approximation in electron-hydrogen scattering. Their main concern is how the identity of incident and orbital electrons yields amplitudes leading to spin polarization effects both with and without the inclusion of spin-orbit forces. I found the chapters worthwhile; the reader who is interested in the theoretical essence of the subject may very well find Burke's book more helpful than Kessler's recent monograph, *Polarized Electrons* (but it will not replace Kessler's book over the whole range of the subject).

Chapter 6 is devoted to effective-range expansions, including modifications induced by the long-range polarization potential, and to quantum defect theory. The chapter also includes a brief discussion of repulsive potentials, but no reference is made to the masterly review by Frank, Land, and Spektor (*Rev. Mod. Phys.* **43**, 36 [1971]), which would have been an invaluable source for the interested reader.

The seventh chapter, on bound states and resonances, is the heart of the book. It covers four topics: the decomposition and analytic structure of the S-matrix, derivation of the time delay formula, the relation of the analytic structure of the S-matrix to effective range expansions, and derivation of Levinson's theorem and Swan's generalization when the target contains particles identical to the projectile. Numerous specific criticisms could be made of the chapter; nevertheless, it is of value to have all this material put together in a concise and convenient form.

Variational and bound principles are the subjects of chapter 8. The chapter also has a concise discussion of the R-matrix method, which is closer to the author's present research. The core of the method is a variational principle for the inner part of the total wave function. The discussion of bounds centers on the derivation of the upper bound expression for the scattering length. For positive energies, however, the book does not include the fundamental approach of Hahn and Spruch, Gailitis, and McKinley and Macek, an omission I believe to be unfortunate.

In the final two chapters the author comes to high energy methods. Here too I believe there are inaccuracies and omissions that cannot be justified by the brevity of the book. For example, no mention is made of the uncertainties concerning the convergence of the Born se-